

ISLAND LAKE



Alberta
ENVIRONMENT

Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Environmental Assessment Division of Alberta Environment.

As you read through the brochure, you may find that you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics**. Refer to this for further interpretation.

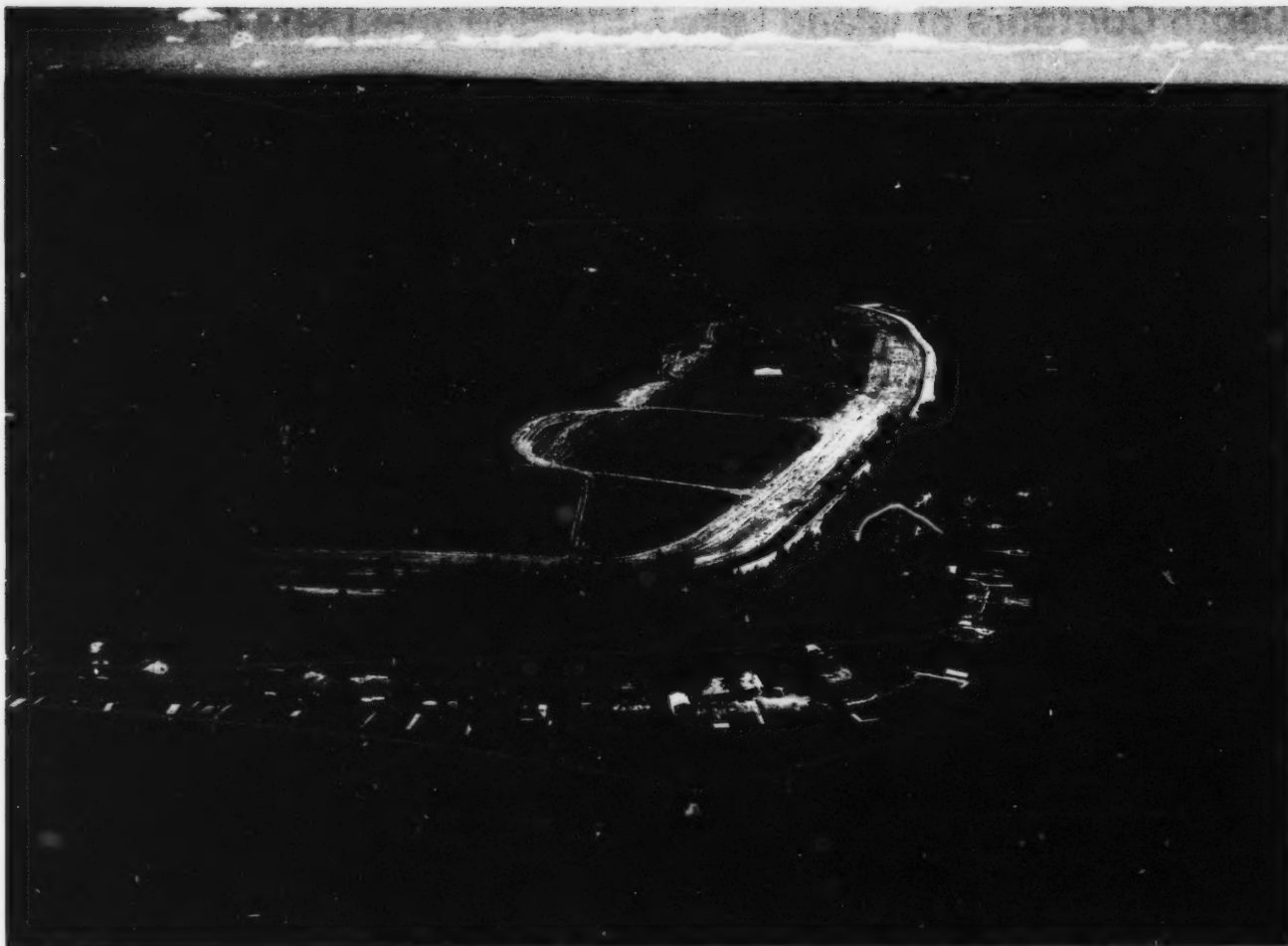
Brochures are available for the following lakes:

Sandy Lake
Lac la Nonne
Wizard Lake
Pigeon Lake
Lake Isle

Pine Lake
Garner Lake
Skeleton Lake
Jackfish Lake
Island Lake

Lac la Biche
Nakamun Lake
Lac Ste. Anne
Baptiste Lake

June 1989



Island Lake is a picturesque, medium-sized lake that is especially attractive for canoeing. It has numerous islands and bays, and the water is often clear. Island Lake is located about 20 km northwest of the town of Athabasca, and is easily accessible from Highway 2, which runs north from Edmonton, through Athabasca and then along the west shore of the lake.

Cottage development began in 1956 on the west shore, and many of the 260 cottages now at the lake are incorporated into two summer villages, Island Lake and Island Lake South. Public access and boat launches are available at several points on the west shore, but at present there are no campgrounds.¹ An island is leased by the Boy Scouts of Canada for camping and pioneering activities and the YMCA

conducts wilderness programs on land on the eastern shore.

Fishing

Fishing is an enjoyable pastime at Island Lake. The lake is managed for sport, commercial and domestic fisheries. Species of fish include whitefish, northern pike (jackfish), yellow perch, white suckers, and perhaps several species of small forage fish. Northern pike are the main target for anglers. Walleye were once present in the lake, but have not been recorded in the commercial catch since 1959/60. The only recorded stocking of walleye was as eggs in 1955. Between 1980 and 1988, the average annual harvest of the two commercially important species was 3,235 kg of lake whitefish and 141 kg of northern pike. The lake is known

for its exceptionally large whitefish.²

Physical Characteristics

Much of Island Lake's charm stems from its convoluted shoreline and its many islands. There are two very different basins that form the lake. As the Depth Contour map shows, the main basin is moderately shallow (maximum depth 12 m) and irregular, whereas the northern basin is oval and quite deep (maximum depth 18 m).

Several small creeks drain into the lake. The largest creek drains from Ghost Lake, which is situated northwest of Island Lake. The outflow, Island Creek, is located on the eastern shore of the main basin. The creek joins the Athabasca River about 3 km to the southeast.

The Historical Water Level graph shows the variations in the

1. Alberta Municipal Affairs. 1980. Island Lake Management Study. prep. for the County of Athabasca and the Summer Village of Island Lake by Planning Services Division.
2. Alberta Forestry, Lands and Wildlife, Fish and Wildlife Division.

Depth Contours of Island Lake

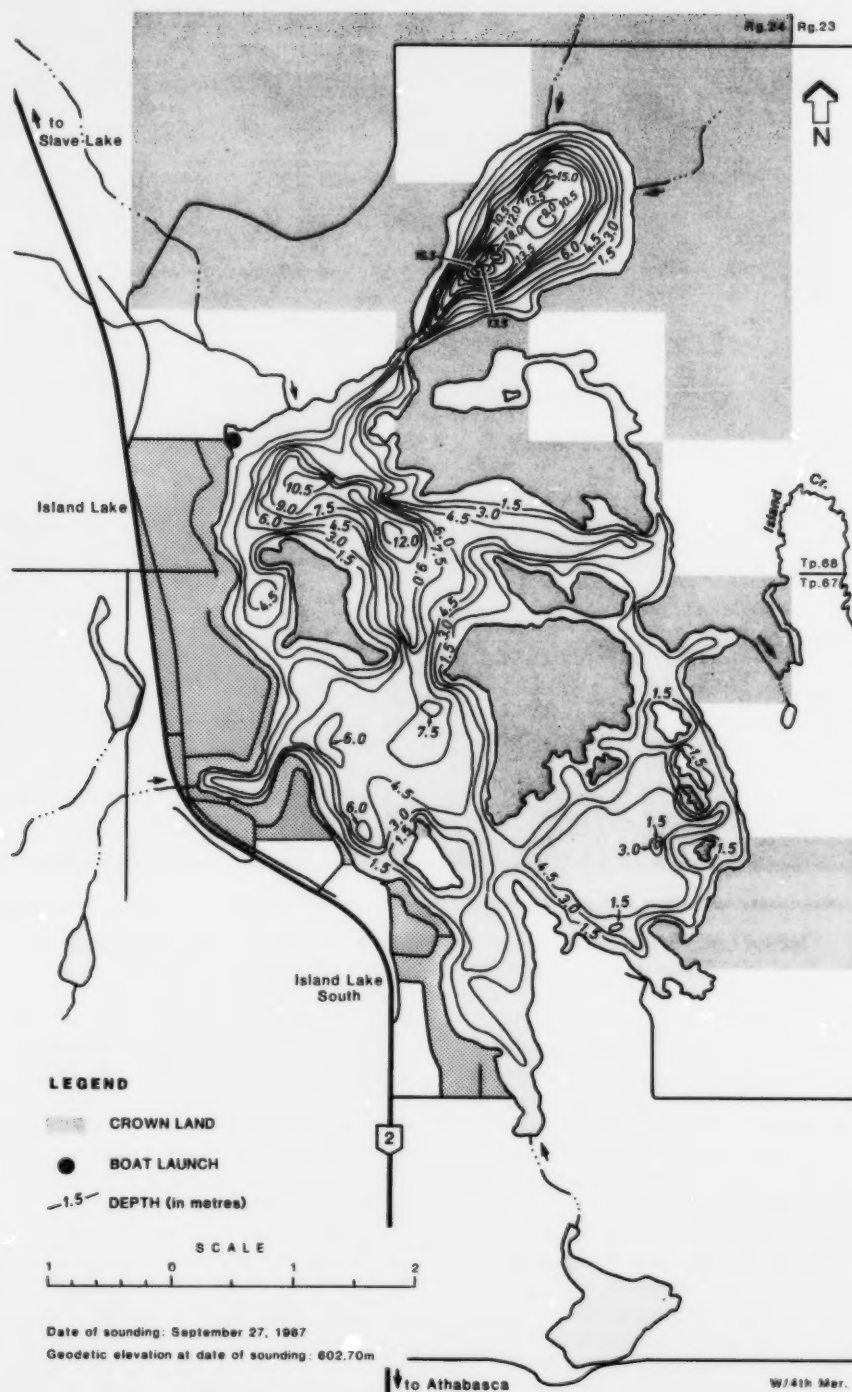
water elevation of Island Lake since 1968. The level has varied between a low of 600.97 m in 1968 to a high of 601.75 m in 1974. This range (0.78 m) is quite small compared to that of many Alberta lakes.

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS*

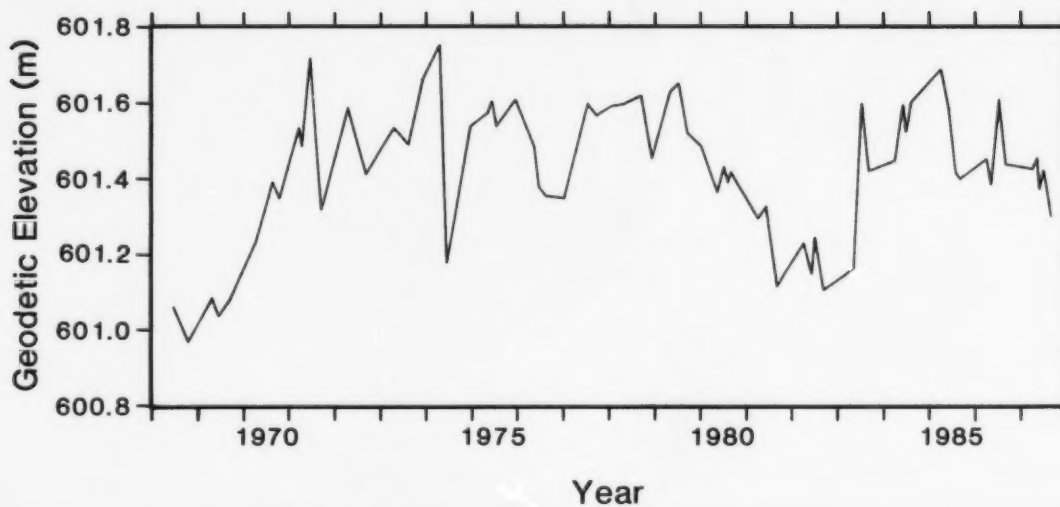
LAKE AREA	km ²	7.81
DRAINAGE AREA (excluding lake)	km ²	63.2
DRAINAGE AREA/ LAKE AREA		8.1
VOLUME	m ³	29.2 x 10 ⁶
MAXIMUM DEPTH	m	18
MEAN DEPTH	m	3.7
SHORELINE LENGTH	km	28
TOTAL INFLOW ^a	m ³ /yr	6.8 x 10 ⁶
TOTAL EVAPORATION	m ³ /yr	5.0 x 10 ⁶
RESIDENCE TIME ^a	years	16

* Reference: Alberta Environment, Technical Services Division, unpublished data for date of sounding, Sept. 1967

^a Excludes groundwater



Historical Water Level of Island Lake



Nutrient Sources

Plant nutrients such as phosphorus and nitrogen stimulate the growth of the shoreline aquatic vegetation that people call "weeds", and also the tiny suspended algae that turn the water green in summer. Usually, the greenness of a lake is related directly to the available supply of phosphorus. Phosphorus and other nutrients enter the lake in creeks, as rain or snow directly onto the lake surface, in runoff over cottage property, and sometimes in effluent from cottage sewage disposal systems. These are called "external" sources because they originate outside the lake. The amount of phosphorus estimated to enter Island Lake in a year is given in the Theoretical External Phosphorus Supply table. The largest supply is in runoff over agricultural or cleared land, even though most of the watershed is forested or in natural bush (see the Watershed map). Agricultural land can contribute as much as five times more phosphorus than a similar area of forest. The amount given in the table for sewage effluent was not measured on Island Lake, but was estimated based on studies conducted on other lakes. Ghost Lake, in the northwest corner of the watershed, traps most of the nutrients from that portion of the watershed and reduces the amount

that would otherwise flow into Island Lake.

The Areal Loading figure in the table (0.10 g/m^2) indicates the annual phosphorus supply per square metre of lake surface. In comparison to many other lakes, Island Lake has a low phosphorus supply. For example, the areal loading value for Baptiste Lake is 0.35 g/m^2 .

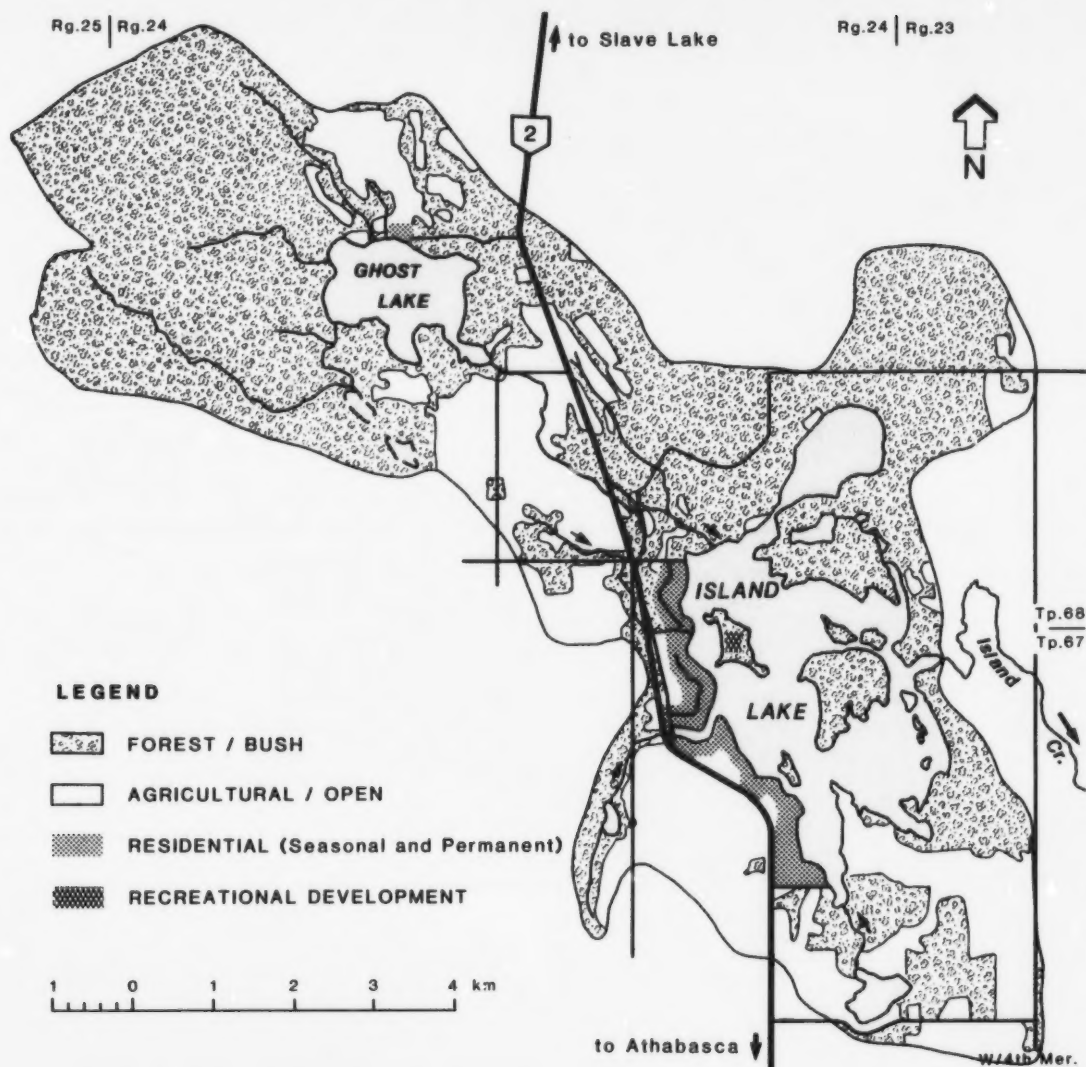
Groundwater inflow may provide an additional supply of phosphorus,

but this has not been studied.

Another probable source is the sediments (mud) at the bottom of the lake. Under certain conditions, particularly when the sediments are warm in summer, phosphorus is released from its attachment on sediment particles. It mixes into the water above and stimulates algal growth. The supply from this "internal" source has not been quantified, but it could be quite significant.



Watershed Map of Island Lake



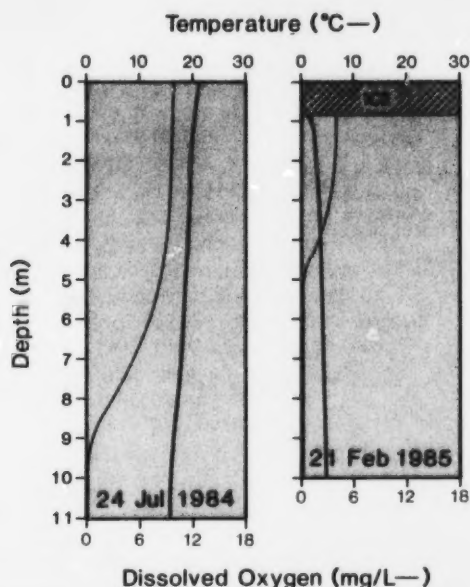
THEORETICAL EXTERNAL PHOSPHORUS SUPPLY*

	kg/year	percentage
SURFACE RUNOFF:		
Forested/Bush	240	29
Cleared/Agricultural	298	37
Residential	67	8
PRECIPITATION, DUSTFALL	172	21
FLOW FROM GHOST LAKE	25	3
SEWAGE EFFLUENT	16	2
TOTAL	818	100
AREA LOADING, g/m² of lake surface	0.10	

Temperature and Dissolved Oxygen

Because the main basin of Island Lake is fairly shallow, it mixes to the bottom when winds are strong. During these periods the water temperature in the main basin is uniform from the lake surface to the bottom, and the lake is well-oxygenated. But on hot, calm days, the surface could warm faster than water at the bottom, so a temperature gradient is established. The Temperature and Dissolved Oxygen graph shows that on 24 July 1984, the surface water was about

Temperature (°C) and Dissolved Oxygen (mg/L) in Island Lake



21°C while the bottom water was only 15°C. This temperature gradient was sufficient to establish a layer of denser water at the bottom, which resisted mixing. As the graph shows, dissolved oxygen declined toward the bottom as it was used up by respiration and decomposition. A day with strong wind would disrupt the layers and oxygen would be restored at the lake bottom.

In the deep north basin, a layer of dense, cold water is established at the bottom of the lake in spring; dissolved oxygen in the bottom layer quickly depletes. This layer remains all summer until the surface water cools, and then the water in the entire lake mixes. From May through

September water below a depth of about 10 m in the north basin is without oxygen, so fish avoid this deep region.

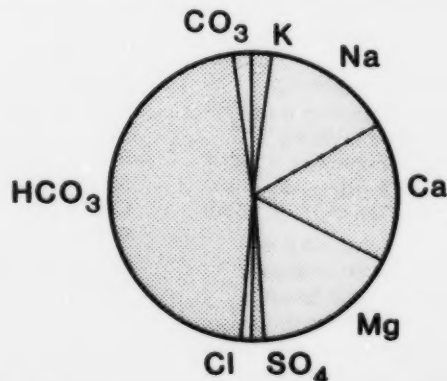
In winter, the warmest water (about 4°C) is at the bottom of the lake, because water is most dense at this temperature. The ice covering the surface of the lake prevents contact with air, and oxygen in the lake water gradually declines. On 21 February 1985, no oxygen remained below a depth of about 5 m in the main basin. Although oxygen concentrations were fairly low in the

surface water, there is only a low risk of winterkill of fish in this lake.

Chemistry

Island Lake is a freshwater lake with low levels of salinity (saltiness) and total dissolved solids. The major ions are bicarbonate (HCO_3), followed by sodium (Na), calcium (Ca) and magnesium (Mg) in similar amounts (see the Ionic Diagram). The concentrations of these substances are well within the range suitable for fish and other aquatic life.

IONIC DIAGRAM Relative Proportions of Ions in Island Lake 1983 - 1984



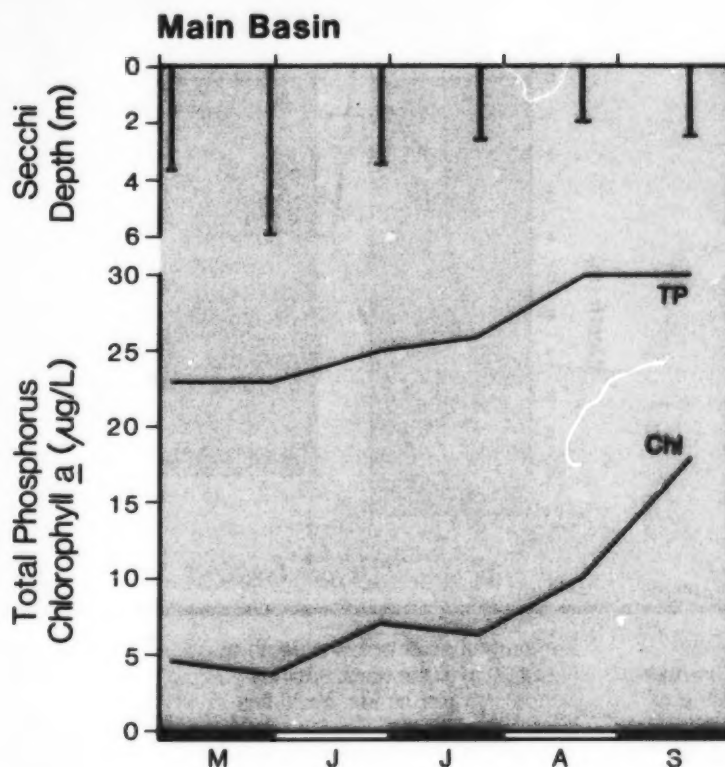
CHEMISTRY Averages Values May - October, 1983-1984

CONDUCTIVITY	$\mu\text{S}/\text{cm}^*$	377
pH (RANGE)		6.7 - 9.1
ALKALINITY	mg/L^{**}	196
TOTAL DISSOLVED SOLIDS	mg/L	203

* microsiemens/cm: a measure of the resistance of the water and its dissolved salts to electrical flow.

** milligrams per litre = parts per million.

Trophic Status of Island Lake



1984

Algae and Trophic Status

The trophic status, or fertility, of a lake is assessed by measuring the amount of nutrients such as phosphorus and nitrogen, and the amount of algae (chlorophyll) in a water sample. The transparency of the water (Secchi depth) also indicates trophic status.

Island Lake has good water quality. The water appears green toward the end of summer, but the lake usually does not develop nuisance blooms of blue-green algae. Its relatively low average chlorophyll and phosphorus levels (see the Trophic Characteristics table) indicate that it is MESOTROPHIC. Because it is deeper, the north basin is slightly less fertile than the main basin.

Chlorophyll a and phosphorus concentrations increased over the summer of 1984, as shown in the

Trophic Status graph. It is typical of this lake that levels of phosphorus and chlorophyll are highest in September or October. Many Alberta lakes have highest levels in July or August. The reason for Island Lake's late peak of algae is not known, but it may relate to a buildup of nutrient-

rich water over the sediments, and then mixing in the fall. As the amount of algae in the water increases, the transparency declines. In 1984, the water was clearest in late May; the 6 m Secchi depth at this time indicates very clear water compared to other lakes in the area.

TROPHIC CHARACTERISTICS Average Values May - October

		1983	1984
PHOSPHORUS	µg/L*	27	26
NITROGEN	µg/L	1087	1161
CHLOROPHYLL	µg/L	11	8
SECCHI TRANSPARENCY	m	3.3	3.4

* micrograms per litre = one millionth of a gram in a litre of water = parts per billion.

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake areas, (i.e. when the **Drainage Area/Lake Area** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar surface area.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time**, which is the time it would take the inflow to completely fill the empty lake basin.

The **Geodetic Elevation** on the water level graph indicates the level or elevation of the lake above mean sea level.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom in summer. Because this colder water is denser, it resists mixing into the warmer, lighter, upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom by wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4°C) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. Oxygen from the air dissolves readily in water, especially on windy days when waves break up the lake surface. The photosynthesis of small aquatic plants also supplies a large amount of oxygen to the lake water.

Oxygen is consumed by respiration of animals and plants, and by the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts towards consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 3 mg/L). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens when an algal bloom "collapses" or dies suddenly.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids**.

The ions* that make up most of this residue can be measured individually. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other. The salinity or saltiness of the water is indicated by its **conductivity**. Water that is low in conductivity (salinity) conducts electricity poorly.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

* Ions: Chemical form in water of constituents such as sodium and carbonate.

pH AND ALKALINITY

The **pH** of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral - neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply relative to all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North America, the quantity of phosphorus contributed by a hectare of forest during runoff is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in several lake watersheds.

In all studies, the phosphorus supply from cleared or agricultural lake was greater than that from forest, averaging 2 to 5 times more.

The **Theoretical Phosphorus Supply** is estimated by multiplying phosphorus supply factors for each type of land use by the area of that land use, and then summing the products.

Similar factors are used for the supply from precipitation. The supply from sewage is estimated based on a percentage of the total amount that could be generated by cottages and camps on the particular lake.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic**. Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic**. In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits certain recreational uses of the lake. Lake users may consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status**.

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/Parkland areas of Alberta ranges between 10 and 200 micrograms per litre* ($\mu\text{g/L}$) (oligotrophic to highly eutrophic), and nitrogen ranges between 500 and 3500 $\mu\text{g/L}$.

Transparency of the water declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disk**, which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the **Secchi Transparency**.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll a**, the green photosynthetic pigment.

* equivalent to parts per billion

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